

11-14-00

A

11/13/00

jc961 U.S. PTO

UTILITY PATENT
APPLICATION TRANSMITTALOnly for new non-provisional applications under 37 CFR 1.53(b)
Check Box, if applicable [] Duplicate

Attorney Docket No.

3597-112-01

Total
Pages

25

jc961 U.S. PTO

09/7/1126

11/13/00

First Named Inventor or Application Identifier

WALTER B. HILL, JR., RICHARD L. BARCLAY, JAMES A.
O'MALLEY, RANDALL W. CONROD, JOHN DESJARDINS, AND
ROGER M. PLOURDE

Express Mail Label No. EL352566085US

APPLICATION ELEMENTS FOR:

PAPER MAKING PROCESSES USING ENZYME AND POLYMER
COMBINATIONS

ADDRESS TO:

Assistant Commissioner for Patents
BOX PATENT APPLICATIONS
Washington, D.C. 20231

1. ☒ Fee Transmittal Form (Incorporated within this form) (Submit an original and a duplicate for fee processing)
2. ☒ Application Total Pages [19]
3. ☒ Formal Drawing(s) (35 USC 113) (Figs. 1-3) Total Sheets [3]
4. ☐ Oath or Declaration and Power of Attorney Total Pages []
- a. ☐ Newly executed (original or copy)
- b. ☐ Copy from prior application (37 CFR 1.63(d))
- (for continuation/divisional with Box 17 completed). i. ☐ Deletion of Inventor(s)
- Signed statement attached deleting inventor(s) named in prior application, see 37 CFR 1.63(d)(2) and 1.33(b).
5. ☐ Incorporation by reference (useable if box 4b is checked)
- The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein
6. ☐ Microfiche Computer Program (Appendix)
7. ☐ Nucleotide and/or Amino Acid Sequence Submission (if applicable, all necessary)
- a. ☐ Computer Readable Copy
- b. ☐ Paper Copy (identical to computer copy)
- c. ☐ Statement Verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

8. ☐ Assignment Papers (cover sheet and document(s))
9. ☐ 37 CFR 3.73(b) Statement (when there is an assignee)

Date: November 13, 2000 Label No.: EL352566085US

I hereby certify that, on the date indicated above, I deposited this paper with identified attachments and/or fee with the U.S. Postal Service and that it was addressed for delivery to the Assistant Commissioner for Patents, Washington, DC 20231 by "Express Mail Post Office to Addressee" service.

Donald S. Prater
Name (Print)DS Prater
Signature

UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new non-provisional applications
under 37 CFR 1.53(b))

Attorney Docket No.

3597-112-01

First Named Inventor or Application Identifier

WALTER B. HILL, JR., RICHARD L. BARCLAY, JAMES A.
O'MALLEY, RANDALL W. CONROD, JOHN DESJARDINS, AND
ROGER M. PLOURDE

PAGE 2 OF 3

10. ☐ English translation Document (if applicable)

11. ☐ Information Disclosure Statement

☐ Copies of IDS Citations

Total Pages ☐

12. ☐ Preliminary Amendment

☐ Please cancel claims

13. ☒ Return Receipt Postcard (MPEP 503)

14. ☐ Small Entity Statement(s)

☐ Statement filed in prior application

15. ☐ Claim for Convention Priority

☐ Certified copy of Priority Document(s)

a. Priority of application no. filed on is claimed under 35 USC 119.

The certified copies/copy have/has been filed in prior application Serial No.

(For Continuing Applications, if applicable)

16. ☐ Other

17. If a CONTINUING APPLICATION, check appropriate box and supply the requisite information:

☒ Continuation ☐ Division ☐ Continuation-in-part (CIP) of prior U.S. Provisional Application No. 60/166,330
filed November 19, 2000.

a. ☐ Please amend the specification by inserting after the title:

FEE TRANSMITTAL	Number Filed	Number Extra	Rate	Basic Fee
The filing fee is calculated below				\$710.00
Total Claims	42 - 20	22	x \$18.00	\$396.00
Independent Claims	3 - 3	0	x \$80.00	\$000.00
Multiple Dependent Claims			\$260.00	
			Filing Fee	\$1106.00
Reduction by 1/2 for small entity				\$.00
Fee for recording enclosed Assignment			\$40.00	
TOTAL				\$1106.00

UTILITY PATENT
APPLICATION TRANSMITTAL

(Only for new non-provisional applications Under 37 CFR 1.53(b))

Attorney Docket No.

3597-112-01

First Named Inventor or Application Identifier

WALTER B. HILL, JR., RICHARD L. BARCLAY, JAMES A.
O'MALLEY, RANDALL W. CONROD, JOHN DESJARDINS, AND
ROGER M. PLOURDE

PAGE 3 OF 3

☒ A check in the amount of \$1106.00 is enclosed to cover the filing fee.

☐ Please charge Deposit Account No. 50-0925 in the total amount of \$ to cover the filing fee.
A duplicate of this sheet is attached.

☒ The Commissioner is hereby authorized to charge payment for any additional filing fees required under 37 CFR 1.16 or credit any overpayment to Deposit Account No. 50-0925. A duplicate of this sheet is attached.

18. CORRESPONDENCE ADDRESS

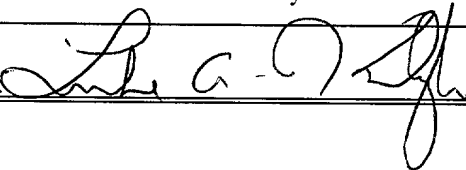
Luke A. Kilyk, Esq.
KILYK & BOWERSOX, P.L.L.C.
3603-E Chain Bridge Road
Fairfax, Virginia 22030
Telephone: (703) 385-9668
Facsimile: (703) 385-9719

SUBMITTED BY

Typed or Printed Name Luke A. Kilyk

Reg. No. 33,251

Signature:



Date: November 13, 2000

Atty. Docket No. 3597-112-01

U.S. Patent Application

Of

Walter B. HILL, Jr., Richard L. BARCLAY, James A. O'MALLEY

Randall W. CONROD, John DESJARDINS, and Roger M. PLOURDE

For

PAPER MAKING PROCESSES USING ENZYME
AND POLYMER COMBINATIONS

PAPER MAKING PROCESSES USING ENZYME
AND POLYMER COMBINATIONS

This application claims the benefit under 35 U.S.C. § 119(e) of prior U.S. Provisional
5 Application No. 60/166,330 filed November 19, 2000, which is incorporated in its entirety by
reference herein.

BACKGROUND OF THE INVENTION

The present invention relates to paper making processes and products made from these
10 processes. More particularly, the present invention relates to treating paper making pulp with a
cellulytic enzyme and one or more polymers.

Particular paper making processes using an enzymatic treatment of paper making pulp
are described in, for example, U.S. Patent Nos. 4,923,565 to Fuentes et al., 5,110,412 to
Fuentes et al., 5,169,497 to Sarkar et al., and 5,308,449 to Fuentes et al., each of which is
15 incorporated herein in its entirety by reference. According to these processes, a paper making
pulp is contacted with an enzyme composition for a substantial period of time before the pulp
is worked on a conventional paper making machine. According to these processes, the pulp
must remain in contact with the enzyme composition for at least 20 minutes before the pulp
can be treated with a conventional synthetic polymeric composition. The contact time allows
20 the enzyme an adequate reaction period prior to addition of the synthetic polymer.
Accordingly, the process requires a separate addition of the synthetic polymer downstream
from where the enzyme first contacts the pulp, which is time consuming and complicated.

There is a need for a paper making process that is simplified and/or avoids the lengthy
contact times.

SUMMARY OF THE INVENTION

The present invention provides a method of making paper or paperboard that includes introducing at least one cellulytic enzyme composition and at least one cationic polymer composition to a paper making pulp at about the same time, to form a treated pulp. The
5 enzyme composition and polymer composition can be added to the pulp separately, or they can be pre-combined and then added. The pulp may also be further treated with at least one cationic starch. The resulting pulp is then formed into a sheet of pulp, preferably having improved drainage and/or retention properties compared to conventional treatments. After drainage and drying, the resulting paper or paperboard preferably exhibits excellent
10 opaqueness and other physical properties.

The present invention further relates to a method of making paper or paperboard that includes treating pulp in a blend chest with a cationic polymer composition and then passing the treated pulp to a machine chest wherein an enzyme composition is added to the treated pulp. The enzyme-treated pulp is then refined and passed to a stuff box. From the stuff box,
15 the pulp is then passed through a white water silo where a second cationic polymer composition is added to the pulp and then the pulp is formed into paper or paperboard.

The present invention also provides a paper making system for carrying out the above-described methods, and paper and paperboard made according to the methods.

It is to be understood that both the foregoing general description and the following
20 detailed description are exemplary and explanatory only and are only intended to provide a further explanation of the present invention, as claimed. The accompanying drawings, which are incorporated in and constitute a part of this application, illustrate several embodiments of the present invention and together with description, serve to explain the principles of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a flow chart showing a paper making process according to an embodiment of the present invention.

Figure 2 is a flow chart showing a paper making process according to another
5 embodiment of the present invention.

Figure 3 is a flow chart showing a paper making process according to another embodiment of the present invention.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

10 The present invention provides methods of making paper or paperboard. In one method, at least one cellulytic enzyme composition and at least one cationic polymer composition are introduced to a paper making pulp at about the same time. The enzyme composition and polymer composition can be added to the pulp separately, or they can be pre-combined and then added. The resulting pulp is then formed into a paper or paperboard.

15 According to the present invention, a cationic starch can also be added to the pulp or treated pulp either at about the same time as the cationic polymer composition and enzyme composition are added, or at a later time. The cationic starch can be the same as or different from the cationic polymer added earlier. Paper and paperboard products made according to the method preferably exhibit excellent opaqueness and/or other physical properties. Sheets of

20 pulp from which the paper and paperboard products are made preferably exhibit excellent drainage and/or excellent retention of pulp fines.

The method of the present invention can be practiced on conventional paper making machines with modifications that can be easily made in view of the present invention. The method can employ many different types of paper making pulp or combinations thereof. For

example, the pulp may comprise virgin and/or recycled pulp, such as virgin sulfite pulp, broke pulp, a hardwood kraft pulp, a softwood kraft pulp, mixtures of such pulps, and the like.

As discussed above, the enzyme composition and the cationic polymer composition are added at about the same time. Preferably, adding these two components at about the same
5 time means that the two components are added within 10 minutes of each other and more preferably are added within 5 minutes of each other and even more preferably are added within 2 minutes or within 1 minute of each other and most preferably are added essentially simultaneously to the pulp.

Furthermore, the enzyme composition and the polymer composition can generally be
10 added at any location of the paper making process but preferably are added prior to the whitewater silo in a paper making process and more preferably are added prior to the machine chest and even more preferably are added prior to the blend chest. Most preferably, the enzyme composition and cationic polymer composition are added prior to the first refiner in a paper making process, which is generally located before the blend chest.

15 The enzyme composition used for treating the pulp may contain any conventional paper making pulp-treating enzyme that has cellulytic activity. Other components can be present as long as these other components do not negatively affect the cellulytic activity of the enzyme composition. Preferably, the enzyme composition also exhibits hemicellulytic activity. Suitable enzymes and enzyme-containing compositions include those described in U.S. Patent
20 No. 5,356,800 to Jaquess, U.S. Patent Application No. 09/031,830 filed February 27, 1998, and International Publication No. WO 99/43780, all incorporated herein in their entireties by reference. Other exemplary paper making pulp-treating enzymes are BUZYME™ 2523 and BUZYME™ 2524, both available from Buckman Laboratories International, Inc., Memphis, Tennessee. The cellulytic enzyme composition preferably contains from about 5% to about

20% by weight enzyme. The preferred enzyme composition can further contain polyethylene glycol, hexylene glycol, polyvinylpyrrolidone, tetrahydrofuryl alcohol, glycerine, water, and other conventional enzyme composition additives, as for example, described in U.S. Patent No. 5,356,800. The enzyme may be added to the pulp in an amount of from about 0.001 to about 0.100% by weight enzyme based on the dry weight of the pulp, for example, from about 0.005 to about 0.05% by weight.

In a preferred embodiment of the present invention, the enzyme composition contains at least one polyamide oligomer and at least one enzyme. The polyamide is present in an effective amount to stabilize the enzyme. Exemplary enzyme compositions containing polyamide oligomers and enzymes are described in International Published Application No. WO 99/43780, which is incorporated herein in its entirety by reference.

According to the present invention, the enzyme composition can include a combination of two or more different enzymes. The enzyme composition can include, for example, a combination of a lipase and a cellulase, and optionally can include a stabilizing agent. The stabilizing agent may be a polyamide oligomer as described herein.

The cationic polymer composition, added to the pulp at about the same time as the enzyme composition, is added in an amount effective to preferably improve the drainage or retention of the pulp compared to no cationic polymer being present. In general, the cationic polymer is added in an amount of at least about 0.5 pound cationic polymer per ton of paperstock, based on dried solids of the pulp, and preferably in an amount of at least about 1 pound per ton of paperstock. Preferably, the cationic polymer is added in an amount of from about 2 pounds per ton of paperstock to about 6 pounds per ton of paperstock, based on dried solids. The cationic polymer may preferably be added in an amount of from about 0.0001% to about 0.0100% by weight based on the dried solids weight of the pulp.

Any cationic polymer or mixture thereof may be used and preferably conventional cationic polymers commonly associated with paper making can be used in the cationic polymer composition. Examples of cationic polymers include, but are not limited to, cationic starches, cationic polyacrylamide polymers, for example, copolymers of an acrylamide with a cationic monomer, wherein the cationic monomer may be in a neutralized or quaternized form.

Nitrogen-containing cationic polymers are preferred. Exemplary cationic monomers which may be copolymerized with acrylamide to form preferred cationic polymers according to the present invention, include amino alkyl esters of acrylic or methacrylic acid, and diallylamines in either neutralized or quaternized form. Exemplary cationic monomers and cationic polyacrylamide polymers are described in U.S. Patent No. 4,894,119 to Baron, Jr., et al., which is herein incorporated in its entirety by reference.

The cationic polymer may also be a polyacrylamide formed from comonomers that include, for example, 1-trimethylammonium-2-hydroxypropylmethacrylate methosulphate. Other examples of cationic polymers, include, but are not limited to, homopolymers of diallylamine monomers, homopolymers of aminoalkylesters of acrylic acids, and polyamines, as described in U.S. Patent No. 4,894,119. Co-polymers, ter-polymers or high forms of polymers may also be used. Further, for purposes of the present invention, a mixture of two or more cationic polymers may be used.

When the cationic polymer is a cationic polyacrylamide, nonionic acrylamide units are preferably present in the copolymer, and preferably present in an amount of at least about 30 mol% and generally in an amount of no greater than 95 mol%. At least about 5 mol%, and generally no greater than about 70 mol%, of the polymer is preferably formed from a cationic comonomer.

The weight average molecular weight of the cationic polymer is preferably over 1,000, for example, from about 10,000 to about 15,000,000, or from about 100,000 to about 10,000,000.

5 In a preferred embodiment of the present invention, the cationic polymer present has a weight average molecular weight of at least about 10,000 and is pre-combined with the enzyme composition before the cationic polymer composition and enzyme composition are added together to the pulp.

10 After treating the paper making pulp with the enzyme composition and cationic polymer composition at about the same time, the resulting treated pulp may then be processed by a conventional paper making machine and techniques. The treated pulp may be additionally treated with one or more components, including other polymers such as anionic and non-ionic polymers, clays, other fillers, dyes, pigments, defoamers, biocides, pH adjusting agents such as alum, and other conventional paper making or processing additives. One particularly preferred additive for use according to the methods of the present invention is a
15 cationic starch.

Cationic starch may be added to the pulp or treated pulp of the present invention to form a starch treated pulp. Starch may be added at one or more points along the flow of paper making pulp through the paper making apparatus or system of the present invention. For instance, cationic starch can be added to a pulp at about the same time that the enzyme and
20 cationic polymer are added to the pulp. The cationic starch can alternatively or additionally be added to the treated pulp after the pulp is first treated with both the enzyme and cationic polymer. Preferred cationic starches include, but are not limited to, potato starches, corn starches, and other wet-end starches, or combinations thereof.

Conventional amounts of starch can be added to the pulp. An exemplary amount of starch that can be used according to the present invention is from about 5 to about 25 pounds per ton based on the dried solids weight of the pulp.

In addition to or in place of the starch, a microparticle additive may be added to the pulp at any time during the process. The microparticle additive can modify the charge of the pulp or the charge of a component of the pulp. The microparticle additive can be, for example, a charging or modifying agent, a filler, a coagulating agent, and/or a retention aid. The microparticle additive can be a natural or synthetic hectorite, bentonite, zeolite, alumina sol, or any of conventional particulate additives as are known to those skilled in the art.

A biocide may be added to the pulp or treated pulp in accordance with conventional uses of biocides in paper making processes. For example, a biocide may be added to the treated pulp in a blend chest after the pulp has been treated with the enzyme and cationic polymer. Biocides useful in the paper making pulps according to the present invention include biocides well known to those skilled in the art, for example, BUSANTM 1130, available from Buckman Laboratories International, Inc., Memphis, Tennessee.

A flow chart of a paper making system for carrying out the method of the present invention is set forth in Figure 1. It is to be understood that the system shown is exemplary of the present invention and is in no way intended to restrict the scope of the invention. In the system of Figure 1, a supply of enzyme composition and a supply of cationic polymer composition are simultaneously combined at desired respective concentrations with a flowing stream of paper making pulp to form a treated pulp. The supply of pulp shown represents a flow of pulp, as for example, supplied from a pulp holding tank or silo. The supply of pulp shown in Figure 1 can be a conduit, holding, or mixing tank, or other container, passageway, or mixing zone for the flow of pulp. The supply of enzyme composition can be, for example,

a holding tank having an outlet in communication with an inlet of a treated pulp tank. The supply of cationic polymer composition can be, for example, a holding tank having an outlet in communication with an inlet of the treated pulp tank.

5 The pulp treated with the enzyme composition and cationic polymer composition is passed from the treated pulp tank through a refiner and then through a blend chest where optional additives including a biocide are combined with the treated pulp. The refiner has an inlet in communication with an outlet of the treated pulp tank, and an outlet in communication with an inlet of the blend chest.

10 According to the embodiment of Figure 1, the pulp treated in the blend chest is passed from an outlet of the blend chest through a communication to an inlet of a machine chest. The blend chest and machine chest can be of any conventional type known to those skilled in the art. The machine chest ensures a level head, that is, a constant pressure on the treated pulp or stock throughout the downstream portion of the system, particularly at the head box.

15 In the system of Figure 1, drained pulp resulting from paper making in the headbox is recirculated to the white water silo.

In the embodiment shown in Figure 2, a cationic starch is added to the refined treated pulp at the blend chest, and the system includes a conventional stuff box. Additional cationic starch may be added at the stuff box although not depicted in Figure 2. The system of Figure 2 has a second refiner between the machine chest and the stuff box. Other additives, including
20 pH adjustment agents such as alum, may also be added at the stuff box. pH adjusting agents can be added at other points along the flow of pulp or treated pulp through the apparatus.

The apparatus of the present invention can also include metering devices for providing a suitable concentration of enzyme to the flow of pulp, for example, from about 0.001 to about 0.100 percent by weight enzyme, based on the dried solids weight of the pulp. The apparatus

can include a metering device for providing a suitable amount of the cationic polymer to the flow of pulp, for example, from about 0.0001 to about 1.000 percent by weight cationic polymer, based on the dried solids weight of the pulp. Other metering or dosing devices are preferably provided for the other additives and ingredients that may be used during the method.

Another embodiment of the present invention is depicted in Figure 3. Pulp is treated in a blend chest with a cationic polymer composition, such as a nitrogen-containing cationic polymer or a cationic starch. The treated pulp is passed from the blend chest to a machine chest wherein an enzyme composition is added to the treated pulp to form an enzyme-treated pulp. The enzyme-treated pulp is then refined and passed to a stuff box where optional cationic polymer composition is optionally added to the pulp. The optional cationic polymer composition, if used, may be the same or different than the first cationic polymer composition, added to the pulp at the blend chest. Alternatively, no additional cationic polymer is added to the pulp at the stuff box. From the stuff box, the pulp is then passed to a white water silo where a nitrogen-containing cationic polymer composition is added to the pulp. The pulp is then passed through a fan pump to a screen and subsequently to a head box. The drained stock resulting from sheet making in the head box is recirculated to the white-water silo.

According to the embodiment of the present invention shown in Figure 3, the nitrogen-containing cationic polymer composition can be, for instance, a cationic polymer containing acrylamide units and units of a cationic monomer. The first cationic polymer composition added, on the other hand, can be a nitrogen-containing polymer, a cationic starch, or another cationic polymer. The optional cationic polymer composition can also be a nitrogen-containing polymer, a cationic starch, or another cationic polymer. The first cationic polymer composition, the nitrogen-containing cationic polymer composition, and the optional cationic

polymer composition can be the same or different. According to a preferred embodiment of the present invention shown in Figure 3, at least one of the cationic polymer compositions and the optional cationic polymer composition comprises a starch. Further, preferably the nitrogen-containing cationic polymer composition contains acrylamide units and units of a cationic monomer.

A cleaner, for example, a centrifugal force cleaning device, can be disposed between, for instance, the fan pump and the screen, according to any of the embodiments of Figures 1-3 above.

The method and apparatus of the present invention provide extended interaction time between the pulp, enzyme, and cationic polymer. Treated pulp reaching the headbox in the system of the present invention can be formed into a paper or paperboard precursor sheet. Preferably, the sheet exhibits excellent drainage and/or retention of fines. Resulting paper and paperboard made according to the method of the present invention exhibit excellent opaqueness and other physical properties.

It will be apparent to those skilled in the art that various modifications and variations can be made to the embodiments of the present invention without departing from the spirit or scope of the present invention. Thus, it is intended that the present invention covers other modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

WHAT IS CLAIMED IS:

1. A method of making paper or paperboard comprising:
 - a) introducing at least one cellulytic enzyme composition and at least one cationic polymer composition to a paper making pulp at about the same time to form a treated
5 pulp; and
 - b) forming the treated pulp into paper or paperboard.
2. The method of claim 1, further comprising introducing at least one first cationic starch to the treated pulp.
3. The method of claim 1, wherein said cellulytic enzyme composition contains
10 from about 5 % to about 20 % by weight enzyme.
4. The method of claim 1, wherein said cellulytic enzyme composition is added to said pulp in an amount of from about 0.100% to about 0.001% by weight enzyme based on the dry weight of the pulp.
5. The method of claim 1, wherein said cellulytic enzyme composition comprises
15 at least one polyamide oligomer and at least one cellulytic enzyme.
6. The method of claim 1, wherein said pulp comprises a sulphite pulp.
7. The method of claim 2, wherein a second cationic starch, which is the same or different from the first cationic starch, is introduced to the treated pulp before step b).
8. The method of claim 1, wherein said at least one cationic polymer composition
20 comprises a synthetic cationic polymer.
9. The method of claim 1, wherein said at least one cationic polymer composition comprises a polyacrylamide polymer.

10. The method of claim 1, wherein said at least one cationic polymer composition is a synthetic, water-soluble cationic polymer containing acrylamide units and cationic monomeric units.

11. The method of claim 1, wherein cationic polymer in said cationic polymer
5 composition is added to said pulp in an amount of from about 0.0001% by weight to about 1.000% by weight, based on the dried solids weight of said pulp.

12. The method of claim 2, wherein said at least one cationic starch is added to said treated pulp in an amount of from about 5 to about 25 pounds per ton based on the dried solids weight of the pulp.

10 13. The method of claim 1, wherein cationic polymer in said cationic polymer composition has a weight average molecular weight of at least about 10,000 and said cationic polymer composition is pre-combined with the enzyme composition before the polymer and enzyme are added together to the pulp.

14. A paper or paperboard made according to the method of claim 1.

15 15. The method of claim 1, wherein the at least one cellulytic enzyme composition and at least one cationic polymer composition are added within ten minutes of each other.

16. The method of claim 1, wherein said at least one cellulytic enzyme composition and at least one cationic polymer composition are added within 5 minutes of each other.

20 17. The method of claim 1, wherein said at least one cellulytic enzyme composition and at least one cationic polymer composition are added within 1 minute of each other.

18. The method of claim 1, wherein said at least one cellulytic enzyme composition and at least one cationic polymer composition are added simultaneously.

19. The method of claim 1, wherein said at least one cellulytic enzyme composition and at least one cationic polymer composition are added prior to a blend chest in a paper making process.

20. The method of claim 19, wherein said at least one cellulytic enzyme
5 composition and at least one cationic polymer composition are added prior to a first refiner which is located before the blend chest.

21. The method of claim 19, further comprising introducing at least one first cationic starch to the treated pulp prior to the blend chest.

22. The method of claim 19, wherein said at least one cationic polymer
10 composition comprises a synthetic polymer having at least one nitrogen-containing polymer.

23. The method of claim 21, further comprising introducing at least a second cationic starch to the treated pulp and wherein said first and second cationic starches are the same or different.

24. The method of claim 1, wherein said pulp is a virgin sulfite pulp.

25. A paper or paperboard made according to the method of claim 23.
15

26. A paper making apparatus comprising a supply of an enzyme composition, a supply of a cationic polymer composition, a supply of a paper making pulp, a device for feeding an enzyme composition from the supply of enzyme composition and cationic polymer composition from the supply of cationic polymer to the supply of paper making pulp at about
20 the same time to form a supply of treated pulp, and a device for forming the treated pulp into a treated paper or paperboard.

27. The apparatus of claim 26, wherein said device for forming the treated pulp comprises a blend chest in communication with said supply of treated pulp, a fan pump in communication with the blend chest, a screen in communication with said fan pump, and a head box in communication with said screen.

5 28. The apparatus of claim 27, wherein a supply tank is provided for holding a supply of the treated pulp, and the communication between said supply tank and said blend chest includes a refining apparatus for refining the treated pulp before entering the blend chest.

30. The apparatus of claim 27, further comprising a supply of cationic starch, an outlet from the supply of said cationic starch in communication with an inlet to said supply of
10 treated pulp and further comprising a white water silo,

wherein said white water silo has an inlet in communication with said blend chest, an inlet in communication with said head box, and an outlet in communication with said fan pump.

30. The apparatus of claim 28, further comprising one or more refiners for refining
15 the pulp or treated pulp prior to forming the pulp in said head box.

31. A method of making paper or paperboard comprising:

- a) introducing a cationic polymer composition to a pulp to form treated pulp;
- b) introducing at least one cellulytic enzyme composition to said treated pulp to form an enzyme-treated pulp;
- 20 c) adding a nitrogen-containing cationic polymer composition to the enzyme-treated pulp; and
- d) forming the pulp into paper or paperboard.

32. The method of claim 31, further comprising introducing a second cationic polymer composition to the enzyme-treated pulp prior to introducing the nitrogen-containing cationic polymer composition to the enzyme-treated pulp.

33. The method of claim 31, wherein said cationic polymer composition comprises
5 a nitrogen-containing polymer or a starch.

34. The method of claim 32, wherein said second cationic polymer composition comprises a nitrogen-containing polymer or a starch.

35. The method of claim 31, wherein said cellulytic enzyme composition contains from about 5% to about 20% enzyme.

10 36. The method of claim 31, wherein said enzyme in said enzyme composition is added to said pulp in an amount of from about 0.001% to about 0.100% by weight enzyme based on the dried solids weight of the pulp.

37. The method of claim 31, wherein said enzyme composition comprises at least one polyamide oligomer and at least one cellulytic enzyme.

15 38. The method of claim 31, wherein said pulp comprises a sulfite pulp.

39. The method of claim 31, wherein said cationic polymer in said cationic polymer composition is added to said pulp in an amount of from about 0.0001% by weight to about 1.000% by weight, based on the dried solids weight of said pulp.

40. A paper or paperboard made according to the method of claim 31.

42. The method of claim 41, wherein said optional cationic polymer is introduced at the stuff box which is located between said machine chest and said whitewater silo.

42. The method of claim 41, wherein said optional cationic polymer is introduced at the stuff box which is located between said machine chest and said whitewater silo.

ABSTRACT

Methods of making paper or paperboard are described. In one method, at least one cellulytic enzyme composition and at least one cationic polymer composition are introduced to a paper making pulp at about the same time to form a treated pulp. The pulp may also be
5 treated with at least one cationic starch. The resulting pulp is formed into a sheet of pulp. Other paper making processes are also described. A paper making apparatus is also described for carrying out the methods. Paper and paperboard made according to the methods are also described.

11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
841
842
843
844
845
846
847
848
849
850
851
852
853
854
855
856
857
858
859
860
861
862
863
864
865
866
867
868
869
870
871
872
873
874
875
876
877
878
879
880
881
882
883
884
885
886
887
888
889
890
891
892
893
894
895
896
897
898
899
900
901
902
903
904
905
906
907
908
909
910
911
912
913
914
915
916
917
918
919
920
921
922
923
924
925
926
927
928
929
930
931
932
933
934
935
936
937
938
939
940
941
942
943
944
945
946
947
948
949
950
951
952
953
954
955
956
957
958
959
960
961
962
963
964
965
966
967
968
969
970
971
972
973
974
975
976
977
978
979
980
981
982
983
984
985
986
987
988
989
990
991
992
993
994
995
996
997
998
999
1000
1001
1002
1003
1004
1005
1006
1007
1008
1009
1010
1011
1012
1013
1014
1015
1016
1017
1018
1019
1020
1021
1022
1023
1024
1025
1026
1027
1028
1029
1030
1031
1032
1033
1034
1035
1036
1037
1038
1039
1040
1041
1042
1043
1044
1045
1046
1047
1048
1049
1050
1051
1052
1053
1054
1055
1056
1057
1058
1059
1060
1061
1062
1063
1064
1065
1066
1067
1068
1069
1070
1071
1072
1073
1074
1075
1076
1077
1078
1079
1080
1081
1082
1083
1084
1085
1086
1087
1088
1089
1090
1091
1092
1093
1094
1095
1096
1097
1098
1099
1100
1101
1102
1103
1104
1105
1106
1107
1108
1109
1110
1111
1112
1113
1114
1115
1116
1117
1118
1119
1120
1121
1122
1123
1124
1125
1126
1127
1128
1129
1130
1131
1132
1133
1134
1135
1136
1137
1138
1139
1140
1141
1142
1143
1144
1145
1146
1147
1148
1149
1150
1151
1152
1153
1154
1155
1156
1157
1158
1159
1160
1161
1162
1163
1164
1165
1166
1167
1168
1169
1170
1171
1172
1173
1174
1175
1176
1177
1178
1179
1180
1181
1182
1183
1184
1185
1186
1187
1188
1189
1190
1191
1192
1193
1194
1195
1196
1197
1198
1199
1200
1201
1202
1203
1204
1205
1206
1207
1208
1209
1210
1211
1212
1213
1214
1215
1216
1217
1218
1219
1220
1221
1222
1223
1224
1225
1226
1227
1228
1229
1230
1231
1232
1233
1234
1235
1236
1237
1238
1239
1240
1241
1242
1243
1244
1245
1246
1247
1248
1249
1250
1251
1252
1253
1254
1255
1256
1257
1258
1259
1260
1261
1262
1263
1264
1265
1266
1267
1268
1269
1270
1271
1272
1273
1274
1275
1276
1277
1278
1279
1280
1281
1282
1283
1284
1285
1286
1287
1288
1289
1290
1291
1292
1293
1294
1295
1296
1297
1298
1299
1300
1301
1302
1303
1304
1305
1306
1307
1308
1309
1310
1311
1312
1313
1314
1315
1316
1317
1318
1319
1320
1321
1322
1323
1324
1325
1326
1327
1328
1329
1330
1331
1332
1333
1334
1335
1336
1337
1338
1339
1340
1341
1342
1343
1344
1345
1346
1347
1348
1349
1350
1351
1352
1353
1354
1355
1356
1357
1358
1359
1360
1361
1362
1363
1364
1365
1366
1367
1368
1369
1370
1371
1372
1373
1374
1375
1376
1377
1378
1379
1380
1381
1382
1383
1384
1385
1386
1387
1388
1389
1390
1391
1392
1393
1394
1395
1396
1397
1398
1399
1400
1401
1402
1403
1404
1405
1406
1407
1408
1409
1410
1411
1412
1413
1414
1415
1416
1417
1418
1419
1420
1421
1422
1423
1424
1425
1426
1427
1428
1429
1430
1431
1432
1433
1434
1435
1436
1437
1438
1439
1440
1441
1442
1443
1444
1445
1446
1447
1448
1449
1450
1451
1452
1453
1454
1455
1456
1457
1458
1459
1460
1461
1462
1463
1464
1465
1466
1467
1468
1469
1470
1471
1472
1473
1474
1475
1476
1477
1478
1479
1480
1481
1482
1483
1484
1485
1486
1487
1488
1489
1490
1491
1492
1493
1494
1495
1496
1497
1498
1499
1500
1501
1502
1503
1504
1505
1506
1507
1508
1509
1510
1511
1512
1513
1514
1515
1516
1517
1518
1519
1520
1521
1522
1523
1524
1525
1526
1527
1528
1529
1530
1531
1532
1533
1534
1535
1536
1537
1538
1539
1540
1541
1542
1543
1544
1545
1546
1547
1548
1549
1550
1551
1552
1553
1554
1555
1556
1557
1558
1559
1560
1561
1562
1563
1564
1565
1566
1567
1568
1569
1570
1571
1572
1573
1574
1575
1576
1577
1578
1579
1580
1581
1582
1583
1584
1585
1586
1587
1588
1589
1590
1591
1592
1593
1594
1595
1596
1597
1598
1599
1600
1601
1602
1603
1604
1605
1606
1607
1608
1609
1610
1611
1612
1613
1614
1615
1616
1617
1618
1619
1620
1621
1622
1623
1624
1625
1626
1627
1628
1629
1630
1631
1632
1633
1634
1635
1636
1637
1638
1639
1640
1641
1642
1643
1644
1645
1646
1647
1648
1649
1650
1651
1652
1653
1654
1655
1656
1657
1658
1659
1660
1661
1662
1663
1664
1665
1666
1667
1668
1669
1670
1671
1672
1673
1674
1675
1676
1677
1678
1679
1680
1681
1682
1683
1684
1685
1686
1687
1688
1689
1690
1691
1692
1693
1694
1695
1696
1697
1698
1699
1700
1701
1702
1703
1704
1705
1706
1707
1708
1709
1710
1711
1712
1713
1714
1715
1716
1717
1718
1719
1720
1721
1722
1723
1724
1725
1726
1727
1728
1729
1730
1731
1732
1733
1734
1735
1736
1737
1738
1739
1740
1741
1742
1743
1744
1745
1746
1747
1748
1749
1750
1751
1752
1753
1754
1755
1756
1757
1758
1759
1760
1761
1762
1763
1764
1765
1766
1767
1768
1769
1770
1771
1772
1773
1774
1775
1776
1777
1778
1779
1780
1781
1782
1783
1784
1785
1786
1787
1788
1789
1790
1791
1792
1793
1794
1795
1796
1797
1798
1799
1800
1801
1802
1803
1804
1805
1806
1807
1808
1809
1810
1811
1812
1813
1814
1815
1816
1817
1818
1819
1820
1821
1822
1823
1824
1825
1826
1827
1828
1829
1830
1831
1832
1833
1834
1835
1836
1837
1838
1839
1840
1841
1842
1843
1844
1845
1846
1847
1848
1849
1850
1851
1852
1853
1854
1855
1856
1857
1858
1859
1860
1861
1862
1863
1864
1865
1866
1867
1868
1869
1870
1871
1872
1873
1874
1875
1876
1877
1878
1879
1880
1881
1882
1883
1884
1885
1886
1887
1888
1889
1890
1891
1892
1893
1894
1895
1896
1897
1898
1899
1900
1901
1902
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
1917
1918
1919
1920
1921
1922
1923
1924
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935
1936
1937
1938
1939
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
2042
2043
2044
2045
2046
2047
2048
2049
2050
2051
2052
2053
2054
2055
2056
2057
2058
2059
2060
2061
2062
2063
2064
2065
2066
2067
2068
2069
2070
2071
2072
2073
2074
2075
2076
2077
2078
2079
2080
2081
2082
2083
2084
2085
2086
2087
2088
2089
2090
2091
2092
2093
2094
2095
2096
2097
2098
2099
2100
2101
2102
2103
2104
2105
2106
2107
2108
2109
2110
2111
2112
2113
2114
2115
2116
2117
2118
2119
2120
2121
2122
2123
2124
2125
2126
2127
2128
2129
2130
2131
2132
2133
2134
2135
2136
2137
2138
2139
2140
2141
2142
2143
2144
2145
2146
2147
2148
2149
2150
2151
2152
2153
2154
2155
2156
2157
2158
2159
2160
2161
2162
2163
2164
2165
2166
2167
2168
2169
2170
2171
2172
2173
2174
2175
2176
2177
2178
2179
2180
2181
2182
2183
2184
2185
2186
2187
2188
2189
2190
2191
2192
2193
2194
2195
2196
2197
2198
2199
2200
2201
2202
2203
2204
2205
22

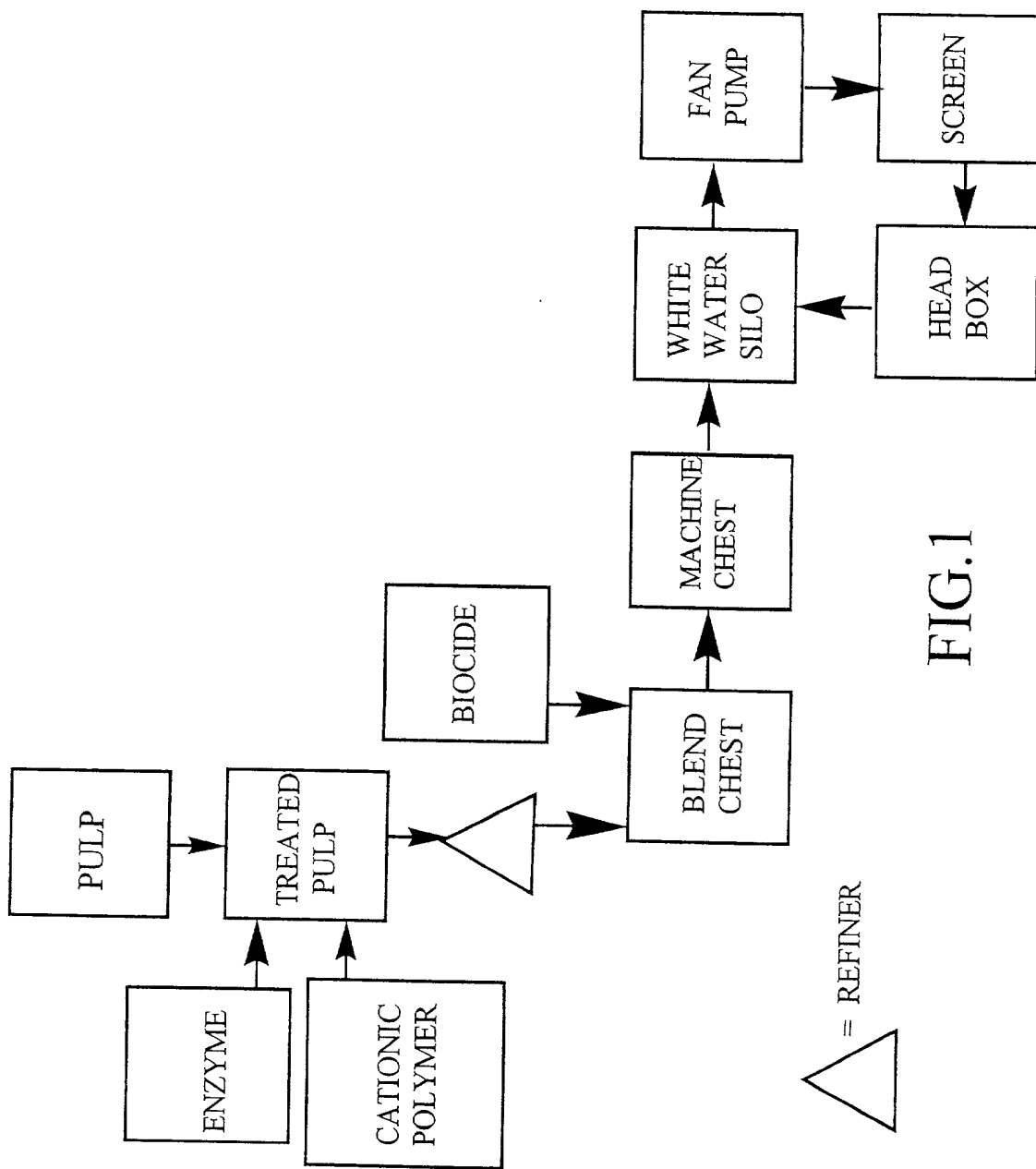


FIG.1

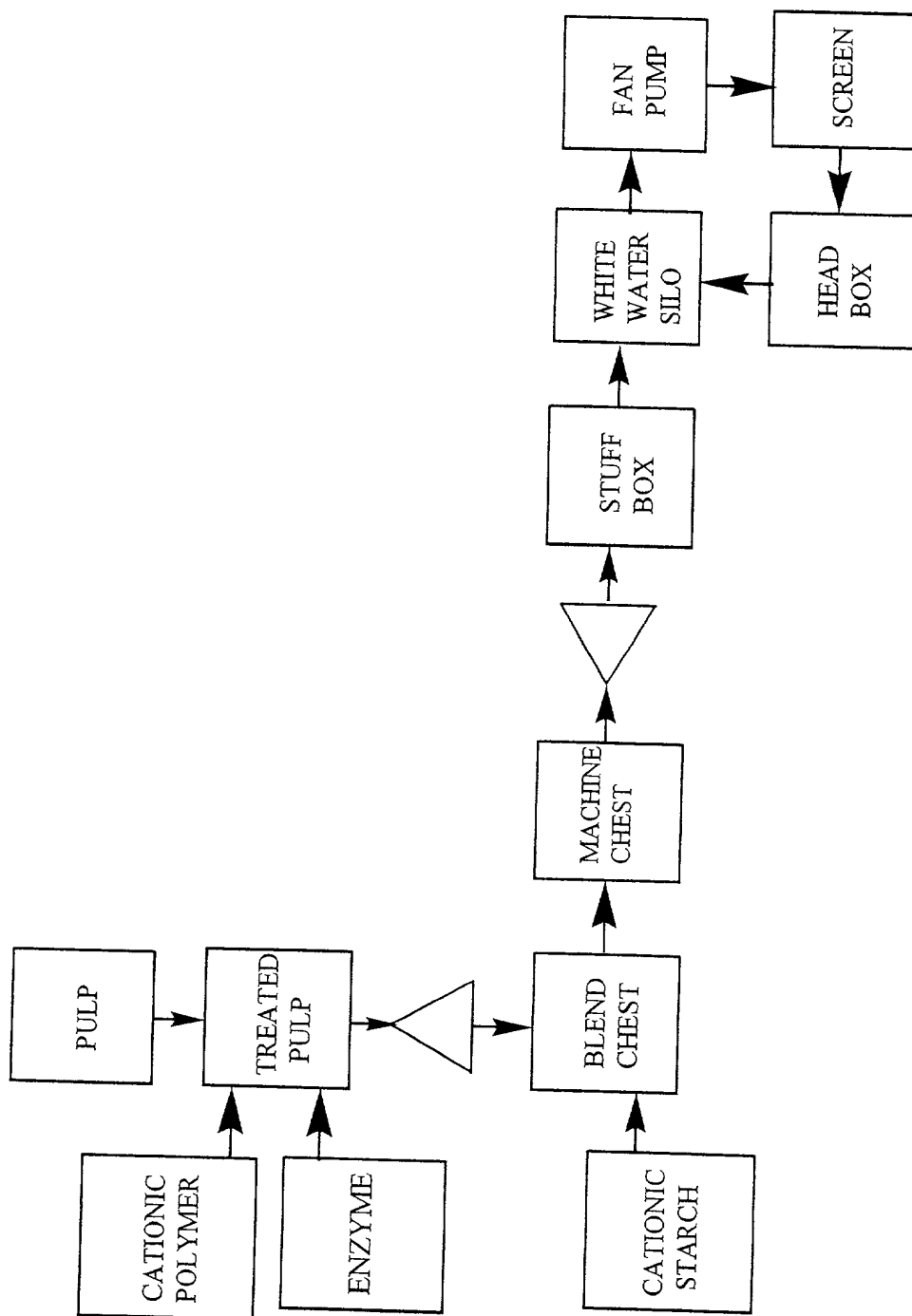


FIG. 2

△ = REFINER

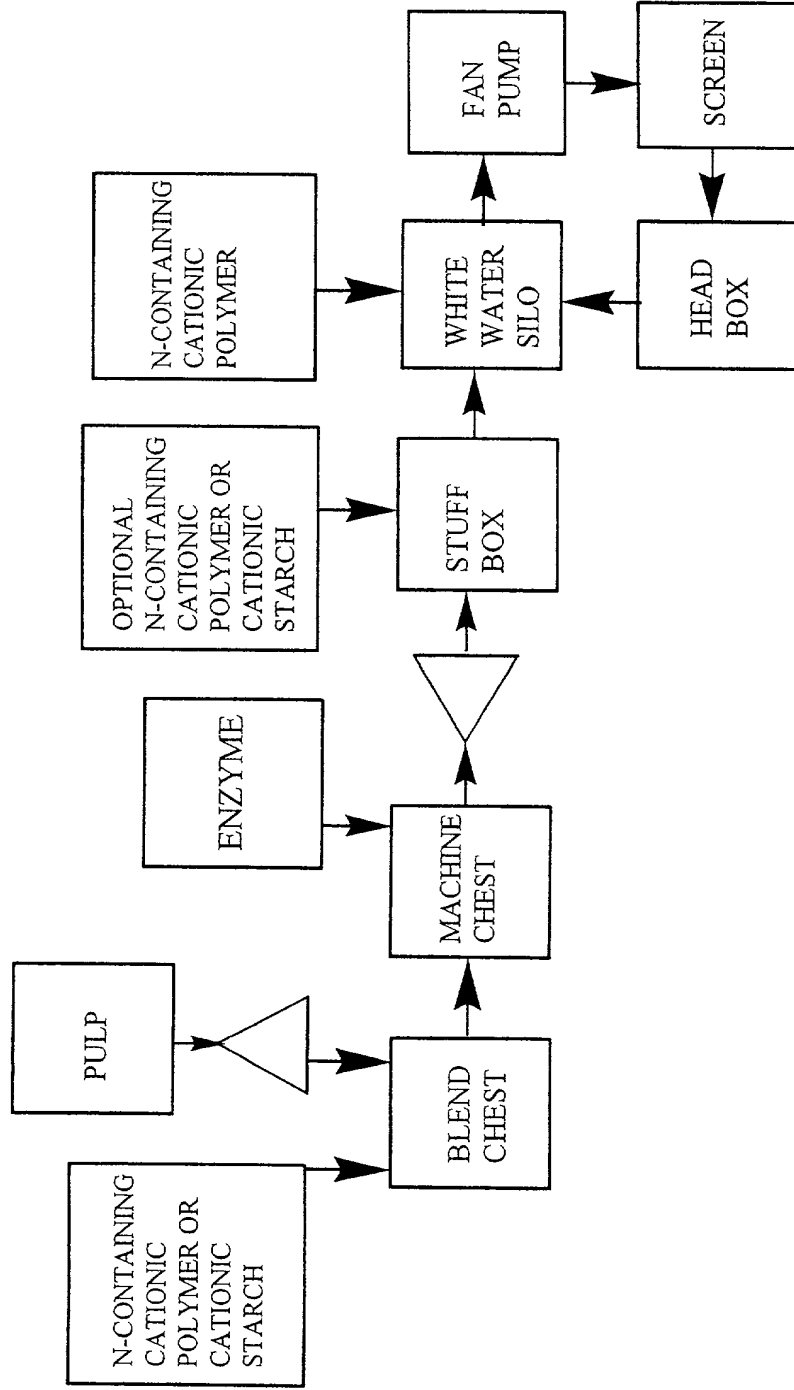


FIG. 3

△ = REFINER